

IN THE CLAIMS

A listing of the claims presented in this patent application appears below. This listing replaces all prior versions and listing of claims in this patent application.

Claims 1 – 62 (Cancelled)

[63] (New) A method for manufacturing a solid-state imaging device in which an imaging region in which a plurality of unit pixels are arranged is provided on a semiconductor substrate, each of the unit pixel including a plurality of element formation regions and an element isolation formation region located between the plurality of element formation regions, the method comprising:

a step (a) of forming, on the semiconductor substrate, a protection film including an opening portion that exposes the element isolation formation region of the semiconductor substrate;

a step (b) of forming a trench by removing a part of the element isolation formation region of the semiconductor substrate by etching using the protection film as a mask;

a step (c) of removing the protection film after the step (b); and

a step (d) of performing thermal treatment in an atmosphere including hydrogen at a temperature in a range between 1000°C and 1300°C, both inclusive, after the step (b).

[64] (New) The method for manufacturing a solid-state imaging device of Claim 63, wherein in the step (d), a semiconductor film of a semiconductor material composing the semiconductor substrate is formed so as to cover an upper part of the trench by the thermal treatment, and

the method further comprising: a step (e) of implanting an impurity having a conductivity type different from that of the element formation regions into the semiconductor film after the step (d).

[65] (New) The method for manufacturing a solid-state imaging device of Claim 63, wherein in the step (d), a semiconductor film of a semiconductor material composing the semiconductor substrate is formed so as to cover an upper part of the trench by the thermal treatment, and the method further comprising: a step (f) of oxidizing the semiconductor film after the step (d).

[66] (New) The method for manufacturing a solid-state imaging device of Claim 63, further comprising: a step (g) of subjecting a side face portion of the trench in the semiconductor substrate to thermal oxidation after the step (b) and before the step (d).

[67] (New) The method for manufacturing a solid-state imaging device of Claim 63, further comprising: a step (h) of forming an insulating film on a side face of the trench after the step (b) and before the step (d).

[68] (New) The method for manufacturing a solid-state imaging device of Claim 63, wherein a peripheral circuit region including a drive circuit for operating the imaging region is provided beside the imaging region in the semiconductor substrate, and an element isolation region of the peripheral circuit region is formed by the same step as a step of forming an element isolation region of the imaging region.

[69] (New) The method for manufacturing a solid-state imaging device of Claim 68, wherein in the peripheral circuit region, only a NMOS transistor, only a PMOS transistor, or a CMOS transistor is formed.

[70] (New) A method for manufacturing a solid-state imaging device in which an imaging region in which a plurality of unit pixels are arranged is provided on a semiconductor substrate,

each of the unit pixel including a plurality of element formation regions and an element isolation formation region located between the plurality of element formation regions, the method comprising:

- a step (a) of forming, on the semiconductor substrate, a protection film including an opening portion that exposes the element isolation formation region and a region located beside the element isolation formation region of the semiconductor substrate;

- a step (b) of forming a sidewall on a side face of the opening in the protection film;

- a step (c) of forming a trench in the element isolation formation region in the semiconductor substrate by etching using the protection film and the sidewall as a mask; and

- a step (d) of forming an element isolation region by burying the trench with a burying film.

[71] (New) The method for manufacturing a solid-state imaging device of Claim 70, further comprising the step of:

- oxidizing a surface portion of the trench in the semiconductor substrate after the step (c) and before the step (d).

[72] (New) The method for manufacturing a solid-state imaging device of Claim 63,

- wherein in the step (a), a width of the opening portion is narrower than a width of the element isolation formation region.

[73] (New) A method for manufacturing a solid-state imaging device in which an imaging region in which a plurality of unit pixels are arranged is provided on a semiconductor substrate, each of the unit pixel including a plurality of element formation regions and an element isolation formation region located between the plurality of element formation regions, the method comprising:

- a step (a) of forming, on the semiconductor substrate, a protection film including an opening portion that exposes a part of the element isolation formation region of the semiconductor substrate;

a step (b) of forming a trench having a depth two time larger than a width thereof by removing a part of the element isolation formation region of the semiconductor substrate by etching using the protection film as a mask; and

a step (c) of forming a TEOS film for burying the trench by CVD after the step (b).

[74] (New) A method for manufacturing a solid-state imaging device provided with, on a semiconductor substrate, an imaging region in which a plurality of unit pixels respectively including photoelectric conversion sections and active regions are arranged,

wherein in a step of forming an element isolation trench between the photoelectric conversion sections and between the respective photoelectric conversion regions and the respective active regions in the semiconductor substrate, a wall of the element isolation trench is tapered.

[75] (New) The method for manufacturing a solid-state imaging device of Claim 74, comprising the step of, after a first insulating film and a second insulting film different in kind from the first insulating film are deposited on the semiconductor substrate sequentially, patterning the first insulating film and the second insulating film before the step of forming the element isolation trench,

wherein the step of forming the element isolation trench includes a step of etching the semiconductor substrate using the patterned first insulting film and the patterned second insulating film as a mask.

[76] (New) The method for manufacturing a solid-state imaging device of Claim 75, wherein in the step of etching the semiconductor substrate, a flow rate of an oxygen gas is set to be 5 % or lower of a flow rate of a chlorine gas.

[77] (New) A solid-state imaging device in which an imaging region in which a plurality of unit pixels are arranged is provided on a semiconductor substrate, each of the unit pixels including a plurality of element formation regions and an element isolation formation region located between the plurality of element formation regions,

wherein in the element isolation formation region, a trench is formed in a part of the semiconductor substrate and a burying film is provided for burying the trench, and

the trench is formed by removing a part of the semiconductor substrate using a protection film which covers the element formation regions of the semiconductor substrate and which includes an opening portion that exposes the element isolation formation region of the semiconductor substrate and a sidewall provided on a side face of the opening portion in the protection film as a mask.

[78] (New) A solid-state imaging device in which an imaging region in which a plurality of unit pixels are arranged is provided on a semiconductor substrate, each of the unit pixels including a plurality of element formation regions and an element isolation region located between the plurality of element formation regions,

wherein in the element isolation region, a trench located in an upper part of the semiconductor substrate is formed, an element isolation film electrically isolating between the plurality of element formation regions is provided so as to cover at least an upper part of the trench, and a cavity is formed at a part within the trench.

[79] (New) A solid-state imaging device comprising:

a semiconductor substrate; and

an imaging region provided on the semiconductor substrate in which a plurality of unit pixels respectively including photoelectric conversion sections and active regions are arranged,

wherein an element isolation trench is formed between the photoelectric conversion sections and between the respective photoelectric conversion sections and the respective active regions, the element isolation trench having a tapered wall.

[80] (New) A solid-state imaging device comprising:

a semiconductor substrate; and

an imaging region provided on the semiconductor substrate in which a plurality of unit pixels respectively including photoelectric conversion sections and active regions are arranged,

wherein an element isolation trench is formed between the photoelectric conversion sections and between the respective photoelectric conversion sections and the respective active regions, a wall face of the element isolation trench forming an angle within a range between 110° and 130°, both inclusive, with respect to a surface of the semiconductor substrate.

[81] (New) The method for manufacturing a solid-state imaging device of Claim 70, wherein the element formation regions of the semiconductor substrate include a n-type impurity, and the method further comprising the step of implanting a p-type ion into a surface portion of the trench in the semiconductor substrate after the step (c) and before the step (d).

[82] (New) The method for manufacturing a solid-state imaging device of Claim 63, wherein a part of the element formation regions of the semiconductor substrate includes a n-type impurity, the method further comprising:
a step (i) of implanting a p-type ion into a surface portion of the trench in the semiconductor substrate after the step (b) and before the step (d).

[83] (New) A camera characterized by using the solid-state imaging device of Claim 77.

[84] (New) A camera characterized by using the solid-state imaging device of Claim 78.

[85] (New) A camera characterized by using the solid-state imaging device of Claim 79.

[86] (New) A camera characterized by using the solid-state imaging device of Claim 80.